USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

TITLE: Denitrification Rates and Controls in Sediments of Illinois Surface Waters

FOCUS CATEGORIES: WCL, SED, NPP

KEY WORDS: Agriculture, Denitrification, Nitrogen, Nutrients, Rivers, Sediments, Streams, Water Quality

DURATION: July 1, 1999 to June 30, 2001

FY 1999 FEDERAL FUNDS REQUESTED: $20,000

FY 1999 NON-FEDERAL MATCHING FUNDS: $48,091

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CONGRESSIONAL DISTRICT: 15th

STATEMENT OF CRITICAL REGIONAL OR STATE WATER PROBLEMS

Recent estimates have shown that agriculture dominates the nitrogen (N) budget of Illinois, with large inputs (fertilization and N fixation, Fig. 1) and outputs (grain harvest, Fig. 2) in the state (M. David, unpublished data). The budget is unbalanced, however, with a large surplus of N estimated each year (about 650,000 Mg N), primarily due to larger inputs of N compared to crop uptake and export. Some of this surplus N is transported to rivers and exported from the state (~200,000 Mg N y-1 for 1994 to 1996), ending up in the Mississippi River. Studies in Illinois have clearly linked agricultural practices, subsurface tile drainage, and river nitrate concentrations (David et al., 1997; Gentry et al., 1998). Many Illinois surface waters, which are often used as drinking water supplies, have nitrate concentrations greater than the EPA standard of 10 mg N L-1. In 1996, the difference between N inputs and outputs was estimated at 650,000 Mg N, and approximately 188,000 Mg of this N was exported from Illinois by the major river systems (Fig. 2). Yet, a large amount of N (461,000 Mg N) was still unaccounted for after subtracting the export by rivers, and determining its fate is critical to better understand what is happening to this large N surplus. Due to concern about the hypoxic zone in the Gulf of Mexico and possible linkages to N in the Mississippi River, along with drinking water problems, we need to fully understand the N budget of Illinois and controls on river N concentrations and export. Currently, N losses from agricultural fields in much of the state are greater than N exports estimated at the mouths of the six major river systems (all expressed on a per ha basis), thereby linking in-stream processing and loss of N. River estimates of N export are made where the rivers enter the Mississippi or Ohio Rivers, and may not reflect all inputs made along long flow paths. Denitrification by microbes in surface waters could account for much of the fate of this missing N, implying larger losses from agricultural fields than would be estimated solely by river N fluxes.

Therefore, denitrification could be a major process in reducing the export of N from Illinois rivers, and of critical importance. Estimates of in-stream denitrification rates would help resolve the linkage between agricultural losses of N to surface water export from the state. We also recognize, however, that a large amount of the surplus N estimated each year in Illinois may be lost through field denitrification, and never reach surface waters. By providing initial estimates of denitrification rates in Illinois surface waters in this study, we will help to put bounds on possible field loss rates of N as well.

STATEMENT OF RESULTS OR BENEFITS

We will use our measurements of denitrification rates to reevaluate N loss from agricultural systems and export in rivers using data from a range of sources. As described previously, N budgets have been and are being made for Illinois agricultural watersheds. Surface water denitrification rates will allow imbalances in budgets to be resolved, and help reduce uncertainty in the fate of N. These data are needed to fully understand the magnitude of N loss from agricultural fields, so that changes can be made to reduce the inputs. In addition, we will know the controls on denitrification rates, which will be needed to better estimate how future N inputs to surface waters may be reduced by this process.

This type of information is critically needed by state and federal agencies that are now considering surface water nutrient criteria and standards, and perhaps management regulations to achieve them. The US EPA, through the President's Clean Water Action Plan of March 24, 1998, is mandated to establish nutrient criteria that reflect different water bodies in the US and to assist States and Tribes in adopting water quality standards based on these criteria (US EPA, 1998). To effectively determine nutrient criteria and standards in agricultural midwestern streams and rivers, we need to know in-stream processing rates of N. Denitirification could be a major factor in reducing nitrate concentrations in surface waters, but few data are available on rates and process controls. Our study will begin to provide this type of data and understanding.

NATURE, SCOPE, AND OBJECTIVES OF THE RESEARCH

We will establish denitrification rates and controls in sediments in a range of Illinois surface waters that currently transport large amounts of N, primarily as nitrate. During the first year we will use acetylene inhibition techniques to determine denitrification rates on sediment samples collected from 40-50 sites in Illinois streams, rivers, and reservoirs. Additional chemical and physical data will be collected to better understand the controls on denitrification rates. In the second year of the study, we will focus on a subset of sites using the acetylene inhibition technique combined with 15N field additions to confirm denitrification rate estimates.

Our objectives are to:

1. measure denitrification rates in sediments sampled from a range of Illinois surface waters, determining regulating factors and identifying representative sites for more detailed studies; and

2. conduct detailed studies to determine denitrification rates seasonally at selected representative sites and make estimates of N loss through denitrification, comparing the loss to estimated inputs and river export.